Contents

1 The Discovery of the Weak Interaction 1
1.1 The Universal Fermi Interaction 3
1.2 The Non-conservation of Parity 11
1.3 Biographical Notes 22

2 Leptonic Interactions 25
2.1 The Current–Current Interaction (Charged Currents) 25
2.2 The Decay of the Muon 27
2.3 The Lifetime of the Muon 40
2.4 Parity Violation in the Muon Decay 45
2.5 The Michel Parameters 56
2.6 The Tau Lepton 74
2.7 Biographical Notes 79

3 Limitations of Fermi Theory 81
3.1 Neutral Currents 81
3.2 Scattering of a Muon Neutrino by an Electron 82
3.3 $\bar{\nu}_\mu$–e^- Scattering 85
3.4 High-Energy Behavior of Neutrino–Electron Scattering 88
3.5 Supplement: Scattering Formalism for Spin-$\frac{1}{2}$ Particles 97
3.6 Divergences in Higher-Order Processes 103
3.7 Biographical Notes 106

4 The Salam–Weinberg Theory 107
4.1 The Higgs Mechanism 107
4.2 The Yang–Mills Field 119
4.3 The Feynman Rules for Yang–Mills Theory 130
4.4 The Glashow–Salam–Weinberg Model of Leptons 146
4.5 Spontaneous Symmetry Breaking: The Higgs Sector 153
4.6 Hidden SU(2) × U(1) Gauge Invariance 168
4.7 Biographical Notes 175

5 Some Properties of the Salam–Weinberg Theory of Leptons 177
5.1 Decay of the Charged Boson W^- 177
5.2 The Process $e^+e^- \to Z^0 \to \mu^+\mu^-$ 182
5.3 High-Energy Behavior of the GSW Theory 197
5.4 Biographical Notes 203

6 Semi-Leptonic Interactions of Hadrons 205
6.1 The World of Hadrons 205

6.2 Phenomenology of Decays of Hadrons 208
6.3 Weak Interactions of Quarks 217
6.4 Cabibbo's Theory of Flavor Mixing 227
6.5 Biographical Notes 246

7 Nuclear Beta Decay 247
7.1 The MIT Bag Model 247
7.2 Beta Decay of the Neutron 253
7.3 Nuclear Beta Decay 260
7.4 Properties of Allowed Beta Decays 263
7.5 Biographical Notes 286

8 The Neutral Kaon System 289
8.1 The Particles K_S and K_L 289
8.2 CP Violation 297

9 Unified Gauge Theories 305
9.1 Introduction: The Symmetry Group SU(5) 305
9.2 Embedding $SU(3)_C \times SU(2)_L \times U(1)$ into SU(5) 311
9.3 The SU(5) Gauge Theory 328
9.4 Spontaneous Breaking of the SU(5) Symmetry 344
9.5 Determination of the Scale of SU(5) Symmetry Breaking 354
9.6 Proton Decay 368
9.7 Outlook: Extensions of the Standard Model 384
9.8 Biographical Notes 388

Appendix 389
A.1 Conventions and "Natural" Units 389
A.2 The Dirac Equation 390
A.3 Feynman Rules 393
A.4 Symmetry Transformations 395

Subject Index 399